Chemistry I: Solution Notes

Solutions defined

- Solutions are defined as _____mixtures of two or more_____.

Suspension, colloids & solutions

- Not all solute/solvent systems are _____
- In true solutions, the _____will not come out of solution with out a change (temp. or pressure)
- Suspensions are _____ mixtures where the particles will settle out.
- Example:_____

- Colloids are between _____and_____

  The particles are dispersed throughout the "solvent" and are _____to see w/ the eye.

Comparison chart solution, suspensions & colloids

Properties	Solutions	Colloids	Suspensions
Type mixture			
Particle size			
Particles settle out			
Can be separated by filtering			
Will scatter light			

Importance

- Solutions are important in chemistry because _____ _____while the reactants are in solution usually a water solution.

Parts of a solution

- No matter how many types of solutions there are all solutions have two basic parts.
- They are:
- 1. Solute _____

- 2. Solvent _____

- 3. The substance in greatest percentage is usually considered to be the _____

Solvents and Solutes

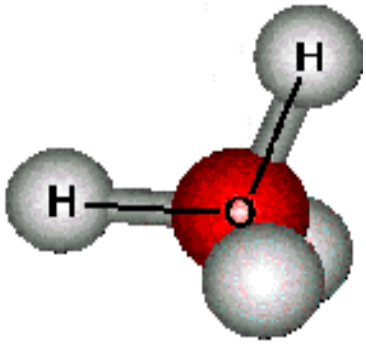
- There are some combinations of solvent and solute that seem not to make solutions.
- The ability of a solute to mix with a solvent is called_____
- Some solutes are only slightly soluble in a given solvent and some solutes are very soluble in a given solvent.

- This appears to also be_____.

There are nine possible combinations

Solvent	Solute	Example
Gas	Gas	
Liquid	Gas	
Solid	Gas	
Gas	Liquid	
Liquid	Liquid	
Solid	Liquid	
Gas	Solid	
Liquid	Solid	
Solid	Solid	

What is the universal solvent?
Water molecule



- Water is the_____solvent because it is a _____solvent.
- Water is polar because of the_____ that develops on the molecule.
- This occurs because _____does not share the electrons equally.
- The electrons from the _____atoms spend most of the time close to

the _____atom. This creates a _____charge

(pole) on the oxygen atom and a _____charge (pole) on each of the

hydrogen atoms.

- **How can alcohols dissolve both polar and nonpolar solutes?**
-
- Alcohols such as methanol, ethanol, and glycols (antifreeze) are both _____

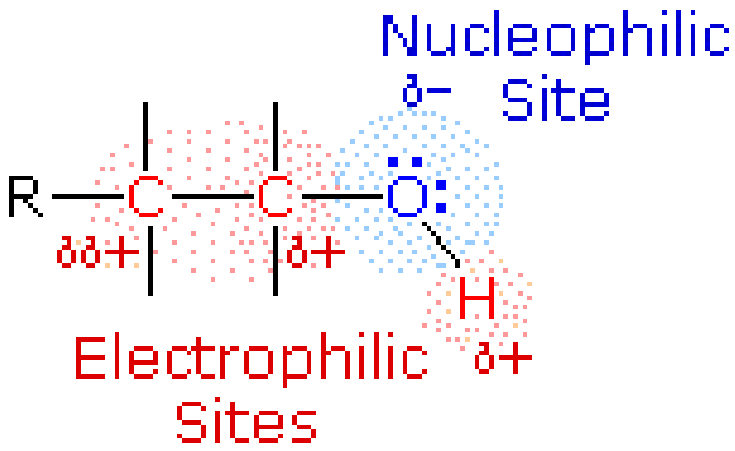
and _____They have a nonpolar end and a polar end.

This is due to the electronic distribution of the electrons on the _____end of the molecule.

- The functional group of the alcohols is the hydroxyl group, **-OH**. The electronegativity of oxygen is substantially greater than that of carbon and hydrogen.
- Consequently, the _____bonds of this functional group are

_____so that oxygen is electron rich.

Alcohol molecule showing polarity



Nonpolar solvents & solutes

- Some _____substances such as carbon tetrachloride

and benzene are _____solvents.

This is due to an _____electronic distribution.

Therefore they will dissolve _____solutes and

will _____dissolve _____compounds.

Solutes & Solvents

•Generally _____molecules will dissolve in polar solvents and non-polar solute molecules will dissolve in non-polar solvents.

•The polar solute molecules have a_____ and a_____ end to the molecule.

If the solvent molecule is also polar, then positive ends of solvent molecules will attract negative ends of solute molecules.

This is a type of intermolecular force known _____.

All molecules also have a type of intermolecular force much weaker than the other forces called _____ where the positive nuclei of the atoms of the solute molecule will attract the negative electrons of the atoms of a _____ molecule.

This gives the non-polar solvent a chance to _____the solute molecules.

" Like dissolves like"

- A General rule applied to solute-solvent relationships goes like this: " Like dissolves like"
- So what does it all mean?
- There are two types of solutes and solvents.
    - They are _____and _____
- SO _____solutes will dissolve in _____solvents and _____solute will dissolve in _____solvents.
- BUT… There are some substances that can be both _____ and _____because of molecular structure.

Solute, Solvents and conditions.

Generally three things affect the solubility of a solute in a solvent.

- They are:
    1. _____
    2. _____
    3. _____
- Some solutes such as gases will respond to _____and _____
- Solid solutes will not be affected by _____but are very sensitive to _____

Le Chateliers Principle can also be applied to solutions

- Most solutions will achieve an _____where the
- amount of _____to amount of _____ is stable at the given conditions.
- However, when a _____occurs the equilibrium will

find a new set of_____.

A stress may be:

1. _____
2. _____
3. _____

The solution will make _____to relieve the stress.

Equilibrium & Saturation

- At equilibrium, the_____ amount of solute is dissolved in the solvent.
- Equilibrium at_____ is dynamic meaning that the saturation point will change if the conditions change.

- What does this mean? It means that some amounts of _____will move in and out of solution.
- If the system is at _____the equal amounts of solute

will _____and_____ at the same time.

Equilibrium & Saturation

- Depending on the direction of the change in the equilibrium two things can happen.
  - First some of the _____may come out of solution as seen in
  - liquid/solid systems where some of the solid _____out or
  - in liquid/ gas systems when the solution seems to _____up.
  - Second the _____may move in a direction to allow
  - the _____to dissolve more solute such as most of the compounds shown on the _____curve.

Solubility redefined

- Therefore we must adjust the definition of solubility to include conditions.
- So, solubility is the _____amount of solute that can dissolve in a given amount of solvent under certain conditions. When a solution reaches this point it is said to be _____. If the solution does not have the maximum amount of solute then its is said to be unsaturated.

a word about concentration.

- Concentration is the amount of _____in a given amount of solvent.
- Two general ways to express this.
  1. The qualitative way uses the terms _____and _____ They are relative terms subject to personal interpretation.

- Dilute means there is a _____amount of solute in the solution.
- Concentrated means a_____ amount of solute in the solution

- The quantative way uses numbers to express the amount of solute in a given amount of solution or solvent.
  - three main terms used are:
    - 1._____
    - 2._____ or (molarity)
    - 3. _____or (molality).

Conditions and Solutions: Pressure

- Pressure has very _____effect on liquid/solid solutions and liquid/liquid solutions.
- But pressure is very _____on liquid/gas solutions.
  - The solubility of a gases _____in liquid solvents when pressure is applied to the solution.
    - The number one example is_____.

Gasses in Solution

- As the pressure on the gas over the solution_____; the concentration of the gas in the solution_____.
- This system follows two laws.
  - Le Chateliers Principle
  - Henry's Law both apply to liquid/gas systems
    - Henry's Law states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas above the liquid.

So what is really going on here?

- It goes like this, if you increase the _____of a gas over a liquid _____gas will dissolve in the liquid and _____concentration of the gas in the liquid.

- The opposite also occurs, _____ the pressure of

the gas over the liquid and the concentration will _____

and some of the gas will _____of solution.

Why did my soda explode?

- Now, if the pressure is _____ quickly the gas will rapidly come of solution.

- The rapid release of a gas from a liquid/gas solution

is called _____.

- Best example: _____

In gas/gas solutions, Dalton's Law of Partial Pressures applies

- If you have a _____of gases as the _____in a

liquid/ gas solution, the _____of each gas solute

is _____ to its partial pressure.

- Or each gas dissolves to the same extent that it would if the other gases were not there.

Temperature and solubility

- Some general things about solubility and temperature.
  - The solubility of a gas _____as the temperature of the solvent increases.

    _____has little is any affect on liquid/liquid solutions.
  - Usually, _____the temperature _____the

    solubility of _____in liquids.
  - Another way to say this is _____temperature increases concentration.

Conditions for solubility of solids in **liquids.**

Three conditions affect the solubility of a solid in a liquid.

- 1. _____
- 2. _____
- 3._____

Temperature & Solubility

- Temperature has the_____ effect on solid in liquid systems.
  - When temperature is _____the dissolving process increases
  - This happens because there is more _____in all if the particles involved and attractive forces are more easily _____

Special conditions can occur when the temperature of a solution decreases

- Let's go through this step-by-step.
  - 1. Increasing the temperature has greatly _____the amount of solid in solution. The solution has reached saturation point.
  - 2. The higher temperature is no longer maintained and the solution is allowed to cool.
  - 3. So, at the new lower temperature the solution still has _____ amount of solute it did at the higher temperature.
  - 4. This creates a very unstable condition called_____.

Supersaturation

- Supersaturation is defined as a condition where an _____amount of

solute remains in solution at a _____temperature.

  - As stated this condition is _____
  - It is so unstable that even a slight _____on the container or addition of a
  - small crystal will cause the excess _to _____out of solution.

Three ways to increase the rate at which a solid will dissolve in a liquid

- 1. _____(increase dispersion of solute)
- 2._____(increases surface area)
- 3. _____ (increases particle activity)

Dissolving Mechanisms

- Three actions occur:
- 1. Solute particles are _____(_____process)
- 2. Solvent particles are _____to make room for the solute particles (_____process)
- 3. Solute particles are _____to the solvent particles (_____process)

Energy and temperature changes doing the dissolving process.

IF:

- net change is_____, temperature _____as
- solid dissolves and solubility _____as temperature increases.
- If net change is_____, temperature _____as
- solid dissolves and solubility _____with increasing temperature

Entropy and dissolving

- Now we are back to this entropy and lower energy state thing.
-
- Natural processes tend to go toward a _____energy state.
-
- If a dissolving process is endothermic; it is because the _____of the
- system _____

- Dissolving a gas into a liquid produces a _____in entropy and is also exothermic.

- So, solubility should decrease with increasing temperature and does.

Heat of Solution

- The heat of solution is the change in_____ that occurs when a substance dissolves in a solvent.!

- It is measured in _____per mole of solute dissolved in a specific number of moles of solvent,

- If dissolving is endothermic, the heat of solution is _____

- If dissolving is exothermic, the heat of solution is _____

Other Stuff

- Solvation is the process by which particles of the _____pull particles of solute away from the solute crystal.

- _____ occurs when molecules of water surround particles of solute ill solution.

Special Terms

- Miscible and Immiscible
  - These apply to liquid/liquid solutions
  -
  - Miscible means the two liquids will _____
    - Example:_____
      - Immiscible means the two liquids will _____
      - Example:_____

Classifying solutions

•It has been found that some water solutions can conduct electricity with some solutes.

–The solutes in those solutions that can conduct electricity are called _____

–The solutes in those solutions that will not conduct electricity are called _____

Colligate Properties

•There are three:

1._____

2._____

3._____

•The reason these properties change is because _____

_____

_____

•Reason: _____

_____

_____

Vapor Pressure Changes

•As solute is added to a solvent, the vapor pressure over the liquid will _____

•As we have previously discussed this will increase the boiling point.

•The math relation looks like this:

$\Delta P_{vapor} \propto m$ where ΔP_{vapor} is the vapor pressure and m is molal concentration.

Freezing point depression

•When a solute is dissolved into a solvent,_____

_____

•This depends on the amount of _____dissolved into the solvent.

•Mathematically: _____

_____

•The additions of solute to a solvent will _____the freezing point.

•This is directly related to the_____ concentration.

•The math relation looks like this:

$\Delta T_f \propto m$ where ΔT is change in temperature and m is molal concentration.

K_f is called the freezing point constant: it is the amt of change (lowering) the fp will undergo for a 1 molal solution.

•The working math looks like this:

$$\Delta T_{fp} = mk_f$$

Boiling Point Elevation

•When a solute is dissolved into a solvent, the _____of the solvent is _____

•This depends on the amount of solute dissolved into the solvent.

•Mathematically the amount the bp _____is directly proportional to the molal concentration.

•The math looks like this:

–$\Delta T_b \propto m$ where ΔT is change in temperature and m is molal concentration.

–K_b is called the boiling point constant: it is the amt of change(raising) the bp will undergo for a 1 molal solution.

The working formula is:

$$\Delta T_{bp} = mk_{bp}$$

Ways of Classifying Solutions

• To review: If the solution:

–can conduct electricity.

–cannot conduct electricity.

•If the solute will conduct electricity::

–produce _____in water solution.

–Break into _____ in water solution.

Substances in water solutions

•Substances that can dissolve in water and the solution can conduct electricity are called *electrolytes*.

•Substances that can dissolve in water and the solution cannot conduct electricity are called *nonelectrolytes.*

•*We will now focus on electrolytes*

Where did the ions come from?

•Theory of ionization

–Faraday – _____

_____

–Arrhenius – _____

_____

•Complete ionization will occur in _____solutions

•Dynamic _____will occur in concentrated solutions (ions go back and forth between solution and molecules)

Dissolving Ionic Compounds

•._____of water very important

•Dipoles on water molecule attract_____.

•This brings the_____ into the solution.

•Energy is _____in the process (exothermic)

•Hydration occurs when water molecules surround the ions.

•The number of water molecules that surround the ion depends on the size of the ion(smaller = fewer; larger = more)

•When the water evaporates, the reverse process occurs.

•The ions will_____.

Energy & Dissolving ionic compounds

•The energy released when ions become surrounded by water molecules is called_____.

•More energy is released when _____ions are hydrated then when large ions are hydrated.

•The energy released or absorbed depends on the relative amounts of energy needed

–1. _____

–2. _____

Dissociation

•The separation of ions that occurs _____

_____is called *dissociation.*

Solubility and Equilibria

•Ionic compounds have different degrees of solubilities from_____

_____.

•Even those ionic compounds that are _____will dissociate to some degree.

Slightly soluble ionic compounds in water:

–An equilibrium will occur between the ions and the crystal

–The solution will be _____

Solubility of 2 cmpds

•Two slightly soluble ionic compounds in water; look like this:

–$AgCl_{(s)}$ $\quad Ag^{+1}_{(aq)} + Cl^{-1}_{(aq)}$

–$Fe(OH)_{3\,(s)}$ $\quad Fe^{+3}_{(aq)} + 3\,OH^{-1}_{(aq)}$

Precipitation Reactions

•When two solutions of highly soluble compounds are mixed together; they may produce_____.

•This is really a double replacement reaction.

•The majority of the slightly soluble compound will _____

_____

•The ions of the remaining compound will stay in solution_____.

Ionic Equations

•Ionic equations show the ions of the compounds in_____.

•The *complete ionic equation* shows _____

_____

_____The net ionic equations shows those ions(on the left) _____

_____

•Ionic Equations

•The double replacement version:

$$AgNO_3 + KCl \text{ .....} > KNO_3 + AgCl$$

•The complete ionic equation:

$$Ag^{+}_{(aq)} + NO_3^{-1}{}_{(aq)} + K^{+}_{(aq)} + Cl^{-1}{}_{(aq)} \text{.....} > K^{+}_{(aq)} + NO_3^{-1}{}_{(aq)} + AgCl_{(s)}$$

•The net ionic equation will look like this:

$$Ag^{+}_{(aq)} + Cl^{-1}{}_{(aq)} \text{ .....} > AgCl_{(s)}$$

The ions that do not make up the _____and remain in the solution are called *spectator ions*.

Molecular electrolytes

•So far in our discussion, all of the compounds have been ionic. BUT there are some molecular compounds that will conduct electricity in water solutions.

Solution process for molecular electrolytes

•When a molecule containing _____is dissolved in water, the dipoles of the water attach to the charged areas of the polar molecules.

•For nonelectrolytes, the complete molecule goes into solution.

•For electrolytes, the weak covalent bonds are broken in the molecule; forming ions.

•Examples of these compounds are: HCl,HF,HBr

Formation of hydronium ions

•When hydrogen ions are formed in a solution a special type of ion forms.

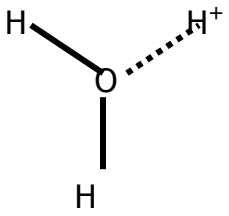
–Hydrogen ions are just a proton because the electron has been removed or stayed with the more electronegative atom.

–Hydronium ions are hydrated hydrogen ions.

•A hydrogen ion with one water molecule.

Hydronium ion

The ion is written this way : H_3O^+



Strong and weak electrolytes

•A strong electrolyte is a substance that will completely ionization(come apart 100%) in dilute solution.

–Examples: HCl and any soluble compound can exist as ions when dissolved

•A weak electrolyte is a substance that produces a low number of ions in solution.

–Example: HF(because HF is in solution as more molecules than ions)

Properties of electrolyte solutions

•Conductivity of solutions

–These solutions will conduct_____.

•They will also depress the fp and elevate the bp of the solvents

Colligative properties of electrolyte solutions

•Freezing point depression has been observed in solutions produced by electrolytes in water. BUT…….

–Electrolytes in water appear to_____.

–Example:

•A 1 molal solution of sugar will lower the fp of a water solution to –1.86 ^{o}C.

•A 1 molal solution will lower the fp of a water solution to approximately –3.72 ^{o}C.

Apparent degree of ionization

•If we carefully calculate the fp of a 1 *m* solution of NaCl we find that –3.72 ^{o}C only works at low molal concentrations.

•But at higher concentrations the fp is higher than the predicted –3.72 ^{o}C.

•So does this solute really come apart 100%?

Apparent degree of ionization

•It appears that the _____ _____a solution has a lot to do with the changes in fb & bp of a solvent(in this case water).

•A number of water molecules will cluster around an ion.

•The number of water molecules involved depends on the charge and size of the ion.

Apparent degree of ionization

•The size of these ion-water clusters causes the changes.

•As with any system, equilibrium will be established.

•Some ions will _____solution and some _____to the solid crystal.

•The degree that this occurs is called_____.

Ionization of water

•It appears that water is a very weak electrolyte. This means that water spends most of its time as molecules.

•A few water molecules will ionize to form hydronium ions and hydroxide

–2 molecules in 1 billion will ionize

Ionization of water

•The equations to show this looks like this:

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^{-1}$

So absolutely pure water will not conduct much electricity.

BUT tap water will and electricity and tap water can be quite dangerous. Why?

remember water is the universal solvent and will dissolve stuff where ever it travels!!!!!

Debye-Hückel Theory

•The ions of solute are clustered_____.

•These clusters can act like_____.

•This reduces the total number of particles in the solution thus _____

_____